

1 **PROCESS FOR THE OLIGOMERIZATION OF OLEFINS**
2 **IN FISCHER-TROPSCH DERIVED FEEDS**

3
4 FIELD OF THE INVENTION

5
6 This invention relates to the oligomerization of olefins present in
7 Fischer-Tropsch derived feeds by use of an ionic liquid oligomerization
8 catalyst.

9
10 BACKGROUND OF THE INVENTION

11
12 The economics of a Fischer-Tropsch complex has in the past only been
13 desirable in isolated areas where it is impractical to bring the natural gas to
14 market; however, a Fischer-Tropsch complex can benefit if the production of
15 high-value products in the product slate, such as lubricating base oil and high
16 quality diesel, can be increased. Fortunately, the market for lubricating base
17 oils of high paraffinicity is continuing to grow due to the high viscosity index,
18 oxidation stability, and low volatility relative to viscosity of these molecules.
19 The products produced from the Fischer-Tropsch process contain a high
20 proportion of wax which makes them ideal candidates for processing into lube
21 base stocks. Accordingly, the hydrocarbon products recovered from the
22 Fischer-Tropsch process have been proposed as feedstocks for preparing
23 high quality lube base oils.

24
25 If desired, high quality diesel products also may be prepared from the
26 syncrude recovered from the Fischer-Tropsch process. Fischer-Tropsch
27 derived diesel typically has very low sulfur and aromatics content and an
28 excellent cetane number. In addition, the process of the present invention
29 makes it possible to produce diesel having low pour and cloud points which
30 enhance the quality of the product. These qualities make Fischer-Tropsch
31 derived diesel an excellent blending stock for upgrading lower quality
32 petroleum-derived diesel.

1 Accordingly, it is desirable to be able to maximize the yields of such higher
2 value hydrocarbon products which boil within the range of lubricating base oils
3 and diesel. At the same time, it is desirable to minimize the yields of lower
4 value products such as naphtha and C₄ minus products. Unfortunately, most
5 Fischer-Tropsch processes produce lower molecular weight olefinic products
6 within the C₃ to C₈ range. The present invention makes it possible to increase
7 the yield of higher boiling products and also increase the amount of branching
8 in the molecules.

9
10 All syncrude Fischer-Tropsch products as they are initially recovered from the
11 Fischer-Tropsch reactor contain varying amounts of olefins depending upon
12 the type of Fischer-Tropsch operation employed. In addition, the crude
13 Fischer-Tropsch product also contains a certain amount of oxygenated
14 hydrocarbons, especially alcohols, which may be readily converted to olefins
15 by a dehydration step. These olefins may be oligomerized to yield
16 hydrocarbons having a higher molecular weight than the original feed.
17 Oligomerization also introduces desirable branching into the hydrocarbon
18 molecule which lowers the pour point of the diesel and lubricating base oil
19 products, thereby improving the cold flow properties of the product. See, for
20 example, U.S. Patent No. 4,417,088. For those Fischer-Tropsch products
21 intended as feed for a hydrocracking operation, a further advantage is that the
22 branching renders the molecule easier to crack. Most of the oxygenates from
23 the Fischer-Tropsch operation will be included in the condensate fraction
24 recovered from the unit. As used in this disclosure, the term "Fischer-Tropsch
25 condensate" refers generally to the C₅ plus fraction which has a lower boiling
26 point than the Fischer-Tropsch wax fraction. That is to say, the condensate
27 represents that fraction which is normally liquid at ambient temperature. In
28 contrast, "Fischer-Tropsch wax" refers to the high boiling fraction from the
29 Fischer-Tropsch derived syncrude and is most often a solid at room
30 temperature.

1 One method for introducing branching into Fischer-Tropsch-derived products
2 is to oligomerize the olefins which are present in the condensate recovered
3 from the Fischer-Tropsch reactor. The oligomerization of olefins introduces
4 branching into the carbon backbone. As already noted, branching results in
5 desirable lubricating properties. U.S. Patent No. 4,417,088 describes a
6 process for oligomerizing olefins to produce molecules having desirable
7 branching. In addition, oligomerization increases the yield of higher boiling
8 products, such as lubricating base oils and diesel, and lowers the yield of
9 lower boiling products, such as LPG and naphtha, from the Fischer-Tropsch
10 operation. Recently, the use of ionic liquid catalysts has been proposed for
11 use in the oligomerization of olefins. See, for example, U.S. Patent
12 Nos. 5,304,615 and 5,463,158. See also European Patent Application
13 No. EP 0791643 A1. U.S. Patent No. 6,395,948 teaches that the
14 oligomerization of alphaolefins using an ionic liquid catalyst must be
15 conducted in the absence of an organic diluent if a polyalphaolefin having a
16 high viscosity is desired.

17

18 Applicants have found that the presence of oxygenates interferes with the
19 oligomerization of olefins when an ionic liquid catalyst is used. Therefore,
20 Applicants have found that it is necessary to remove the oxygenates from the
21 feed prior to the oligomerization step, such as by use of an adsorbent. X-type
22 zeolites, especially 13X zeolite, have been found to be particularly useful in
23 carrying out the present invention. U.S. Patent No. 2,882,244 discloses the
24 use of X zeolites as adsorbents. The use of 13X zeolite as an adsorbent is
25 taught U.S. Patent No. 4,481,018 to Coe et al.

26

27 As used in this disclosure, the words "comprises" or "comprising" is intended
28 as an open-ended transition meaning the inclusion of the named elements,
29 but not necessarily excluding other unnamed elements. The phrases "consists
30 essentially of" or "consisting essentially of" are intended to mean the
31 exclusion of other elements of any essential significance to the composition.
32 The phrases "consisting of" or "consists of" are intended as transitions

1 meaning the exclusion of all but the recited elements with the exception of
2 only minor traces of impurities.

3 4 BRIEF DESCRIPTION OF THE INVENTION

5
6 In its broadest aspect, the present invention is directed to a process for
7 oligomerizing the olefins present in a Fischer-Tropsch derived condensate
8 containing a mixture of olefins and oxygenates which comprises (a) reducing
9 significantly the oxygenates present in the Fischer-Tropsch condensate;
10 (b) contacting the Fischer-Tropsch derived condensate having significantly
11 reduced oxygenates with an ionic liquid catalyst in an oligomerization zone
12 under oligomerization reaction conditions; and (c) recovering from the
13 oligomerization zone a Fischer-Tropsch derived product having molecules
14 characterized by a higher average molecular weight and increased branching
15 as compared to the Fischer-Tropsch derived condensate.

16
17 The present invention is also directed to a process for preparing a
18 Fischer-Tropsch derived product by the oligomerization of the olefins in a
19 Fischer-Tropsch derived concentrate which contains olefins and oxygenates
20 which comprises (a) dehydrating the Fischer-Tropsch derived concentrate in a
21 dehydration zone under dehydration conditions and recovering a dehydrated
22 Fischer-Tropsch derived condensate from the dehydration zone;
23 (b) contacting the dehydrated Fischer-Tropsch derived condensate with a
24 molecular sieve capable of adsorbing the oxygenates remaining in the
25 dehydrated Fischer-Tropsch derived condensate and recovering a
26 Fischer-Tropsch derived condensate intermediate containing significantly
27 reduced oxygenates; (c) contacting the Fischer-Tropsch derived condensate
28 intermediate in an oligomerization zone with an effective oligomerizing
29 amount of an acidic ionic liquid oligomerization catalyst while maintaining said
30 Fischer-Tropsch derived condensate intermediate and said oligomerization
31 catalyst under preselected oligomerization conditions for a sufficient time to
32 oligomerize the olefins present; and (d) recovering from the oligomerization
33 zone a Fischer-Tropsch derived product having molecules characterized by a

1 higher average molecular weight and increased branching as compared to the
2 Fischer-Tropsch derived condensate.

3
4 It has been found that oxygenates present in Fischer-Tropsch derived feeds
5 interfere with the ability of an ionic liquid oligomerization catalyst to promote
6 the oligomerization of the olefins present in the condensate. Surprisingly, this
7 interference occurs even when the Fischer-Tropsch feed is first subjected to a
8 dehydration step which converts substantially all of the alcohols present into
9 olefins. It has been discovered that even low levels of other oxygenates, such
10 as ketones and carboxylic acids, which remain in the condensate after the
11 dehydration step will deactivate the ionic liquid catalyst. Therefore, it is
12 essential when an ionic liquid catalyst is employed to oligomerize the olefins
13 in the condensate fraction to significantly the remaining oxygenates present.
14 Preferably, substantially all of the remaining oxygenates are removed prior to
15 oligomerization.

16
17 Any of a number of methods may be used for removing the oxygenates from
18 Fischer-Tropsch derived feeds. For example, the addition of sodium metal to
19 the condensate may be employed to reduce the oxygenates. A more
20 commercially practical way of removing oxygenates is by the use of an
21 adsorbent, such as, for example, a molecular sieve having a low silica to
22 alumina ratio. Large pore molecular sieves having low silica to alumina ratio,
23 particularly those molecular sieves characterized as having an FAU type of
24 framework, may be suitable for use as an adsorbent for oxygenates. Preferred
25 FAU molecular sieves are X zeolites, with 13X zeolite being particularly
26 preferred.

27
28 Following removal of the oxygenates, the olefins in the condensate are
29 oligomerized using an effective oligomerizing amount of a Lewis acid ionic
30 liquid catalyst.

31
32 Following oligomerization, it is usually desirable to saturate the remaining
33 double bonds in the hydrocarbon molecules of the Fischer-Tropsch derived

1 products. This operation, referred to herein as hydrofinishing, improves the
2 UV and oxygen stability of the products.

3

4

DETAILED DESCRIPTION OF THE INVENTION

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6 As noted above, the oligomerization of the olefins normally present in the
7 condensate recovered from a Fischer-Tropsch operation increases the
8 production of higher value products, such as lubricating base oils and diesel,
9 and also introduces desirable branching into the molecules which helps to
10 improve the cold flow properties of the products. The use of an ionic liquid
11 catalyst for the oligomerization of the olefins in the condensate has certain
12 advantages over more conventional catalysts, in that there is excellent mixing
13 of the reactants with the catalyst resulting in short residence times and high
14 yields, the oligomerization reactions takes place at relatively low
15 temperatures, and the products are readily separated from the catalyst.
16 However, it has been found that the oxygenates normally present in the
17 Fischer-Tropsch condensate deactivate the catalyst unless they are removed
18 prior to the oligomerization operation. Initially, the oxygenates were not
19 believed to present a major problem, since the condensate recovered from
20 the Fischer-Tropsch operation is usually subjected to a dehydration step prior
21 to the oligomerization step in order to convert substantially all of the alcohols
22 present into olefins. Since most of the oxygenates present in the condensate
23 are represented by alcohols, it was believed that further processing of the
24 condensate was unnecessary prior to oligomertization. However, it was found
25 that other oxygenates were present and even at very low levels deactivated
26 the catalyst. These oxygenates were found to either be passing through the
27 dehydration step unchanged or were being produced in the dehydration step
28 from the alcohols present. Aside from the alcohols, the most important
29 contaminants were found to be ketones and carboxylic acids, with aldehydes,
30 and anhydrides perhaps also causing problems. Therefore, it was found to be
31 essential to include an additional step between the dehydration operation and
32 the oligomerization operation to remove the remaining oxygenates when an
33 ionic liquid catalyst is being utilized.

Fischer-Tropsch Synthesis

During Fischer-Tropsch synthesis, liquid and gaseous hydrocarbons are formed by contacting a synthesis gas (syngas) comprising a mixture of hydrogen and carbon monoxide with a Fischer-Tropsch catalyst under suitable temperature and pressure reactive conditions. The Fischer-Tropsch reaction is typically conducted at temperatures of from about 300 degrees to about 700 degrees F (about 150 degrees to about 370 degrees C), preferably from about 400 degrees to about 550 degrees F (about 205 degrees to about 290 degrees C); pressures of from about 10 to about 600 psia (0.7 to 41 bars), preferably 30 to 300 psia (2 to 21 bars); and catalyst space velocities of from about 100 to about 10,000 cc/g/hr., preferably 300 to 3,000 cc/g/hr.

The products from the Fischer-Tropsch synthesis may range from C_1 to C_{200} plus hydrocarbons with a majority in the C_5 - C_{100} plus range. The reaction can be conducted in a variety of reactor types, such as, for example, fixed bed reactors containing one or more catalyst beds, slurry reactors, fluidized bed reactors, or a combination of different types of reactors. Such reaction processes and reactors are well known and documented in the literature. The slurry Fischer-Tropsch process, which is preferred in the practice of the invention, utilizes superior heat (and mass) transfer characteristics for the strongly exothermic synthesis reaction and is able to produce relatively high molecular weight paraffinic hydrocarbons when using a cobalt catalyst. In the slurry process, a syngas comprising a mixture of hydrogen and carbon monoxide is bubbled up as a third phase through a slurry which comprises a particulate Fischer-Tropsch type hydrocarbon synthesis catalyst dispersed and suspended in a slurry liquid comprising hydrocarbon products of the synthesis reaction which are liquid under the reaction conditions. The mole ratio of the hydrogen to the carbon monoxide may broadly range from about 0.5 to about 4, but is more typically within the range of from about 0.7 to about 2.75 and preferably from about 0.7 to about 2.5. A particularly preferred Fischer-Tropsch process is taught in European Patent Application

1 No. EP 0609079, also completely incorporated herein by reference for all
2 purposes.

3

4 Suitable Fischer-Tropsch catalysts comprise one or more Group VIII catalytic
5 metals such as Fe, Ni, Co, Ru and Re, with cobalt being preferred.

6 Additionally, a suitable catalyst may contain a promoter. Thus, a preferred
7 Fischer-Tropsch catalyst comprises effective amounts of cobalt and one or
8 more of Re, Ru, Pt, Fe, Ni, Th, Zr, Hf, U, Mg and La on a suitable inorganic
9 support material, preferably one which comprises one or more refractory
10 metal oxides. In general, the amount of cobalt present in the catalyst is
11 between about 1 and about 50 weight percent of the total catalyst
12 composition. The catalysts can also contain basic oxide promoters such as
13 ThO₂, La₂O₃, MgO, and TiO₂, promoters such as ZrO₂, noble metals (Pt, Pd,
14 Ru, Rh, Os, Ir), coinage metals (Cu, Ag, Au), and other transition metals such
15 as Fe, Mn, Ni, and Re. Suitable support materials include alumina, silica,
16 magnesia and titania or mixtures thereof. Preferred supports for cobalt
17 containing catalysts comprise alumina or titania. Useful catalysts and their
18 preparation are known and illustrated in U.S. Patent No. 4,568,663, which is
19 intended to be illustrative but non-limiting relative to catalyst selection.

20

21 The products as they are recovered from the Fischer-Tropsch operation
22 usually may be divided into three fractions, a gaseous fraction consisting of
23 very light products, a condensate fraction generally boiling in the range of
24 naphtha and diesel, and a high boiling Fischer-Tropsch wax fraction which is
25 normally solid at ambient temperatures.

26

27 Dehydration

28

29 Although the dehydration step is not essential to the present invention, it is
30 advantageous to enrich the condensate with olefins in order to increase the
31 production of higher molecular products. In order to enrich the condensate
32 with olefins, the alcohols may be dehydrated to convert them into olefins prior
33 to the oligomerization step. In general, the dehydration of alcohols may be

1 accomplished by processing the feedstock over a catalyst, such as gamma
2 alumina. Dehydration of alcohols to olefins is discussed in Chapter 5,
3 "Dehydration" in *Catalytic Processes and Proven Catalysts* by
4 Charles L. Thomas, Academic Press, 1970.

5 6 Removal Of Oxygenates 7

8 The condensate recovered from the Fischer-Tropsch operation will contain
9 varying amounts of oxygenates. The majority of the oxygenates present in the
10 condensate are in the form of alcohols; however, lesser amounts of ketones,
11 aldehydes, carboxylic acids, and anhydrides may also be present. As already
12 noted above, the presence of even small amounts of oxygenates in the feed
13 to the oligomerization operation will result in the deactivation of the ionic liquid
14 catalyst. Although substantially all of the alcohols present in the condensate
15 will be converted to olefins in the dehydration step, it has been found that
16 dehydration is insufficient to remove all of the oxygenates and that sufficient
17 oxygenates will be present in the effluent from the dehydration step to
18 damage the ionic liquid catalyst. Most of these residual oxygenates are
19 believed to be ketones and carboxylic acids. The oxygenate species
20 remaining after dehydration are believed to vary depending on the source of
21 the condensate. For condensate prepared using an iron-based catalyst, the
22 oxygenate species remaining are primarily ketones. For condensate collected
23 from a Fischer-Tropsch operation using a cobalt-based catalyst, the
24 oxygenates appear to be primarily carboxylic acids. It is unclear whether
25 these residual oxygenates result from the failure of the dehydration step to
26 remove them or if some are actually being produced from the alcohols during
27 the dehydration reaction.

28
29 The removal of the oxygenates may be accomplished in various ways, some
30 of which have been previously described in the literature. For example, the
31 oxygenates may be removed by contacting the condensate with sodium
32 metal. While effective, this method is not practical on a commercial scale. A
33 commercially acceptable method for removing the oxygenates involves

1 passing the condensate through an adsorption bed containing an adsorbent
2 capable of adsorbing the oxygenates. A satisfactory adsorbent may include a
3 molecular sieve having low silica to alumina ratio. Large pore molecular
4 sieves having a low silica to alumina ratio, particularly those molecular sieves
5 characterized as having an FAU type of framework, are generally suitable for
6 use as an adsorbent for oxygenates. Preferred FAU molecular sieves are X
7 zeolites, with 13X zeolite being particularly preferred. As used herein, the term
8 "FAU molecular sieve" refers to the IZA Structure Commission standard which
9 includes both X and Y zeolites.

10

11 The synthesis of X-type zeolites is described in U.S. Patent Nos. 2,882,244;
12 3,685,963; 5,370,879; 3,789,107 and 4,007,253 which are hereby
13 incorporated herein by reference in their entirety. 13X Zeolite are a faujasite
14 (FAU) type X zeolite. It has a low silica/alumina ratio and is comprised of
15 silicon, aluminum and oxygen. The oxygen ring provides a cavity opening of
16 7.4 angstroms, but can adsorb molecules up to 10 angstroms. 13X zeolite
17 have a Chemical Abstracts (CAS) number of [63231-69-6]. 13X zeolite are
18 commercially available from several sources, including
19 Aldrich Chemical Company and the Davison Division of W. R. Grace.

20

21 In practicing the present invention, the amount of the oxygenates are
22 significantly reduced in the Fischer-Tropsch derived condensate prior to the
23 oligomerization step. As used herein, "significantly reduced" means that the
24 elemental oxygen remaining in the Fischer-Tropsch derived condensate is
25 about 1500 ppmw or less. Preferably, substantially all of oxygenates are
26 removed prior to oligomerization. Generally, the Fischer-Tropsch condensate
27 should contain less than about 200 ppm elemental oxygen, even more
28 preferably less than 100 ppm elemental oxygen prior to the oligomerization
29 step.

Oligomerization

The use of an ionic liquid catalyst for the oligomerization of the olefins in the present invention has certain advantages over more conventional catalysts, in that there is excellent mixing of the reactants with the catalyst resulting in short residence times and high yields, the oligomerization reaction takes place at relatively low temperatures, and the products are readily separated from the catalyst. As noted above, it is essential that the oxygenates present in the feed to the ionic liquid oligomerization operation be reduced to the lowest practical level. The condensate following removal of the oxygenates will consist essentially of an olefin enriched hydrocarbon feed composed mostly of molecules containing between about 5 and about 19 carbon atoms, i.e., that fraction which is normally liquid at ambient temperature. Stated differently, the condensate will comprise primarily saturated and unsaturated hydrocarbons boiling within the range of naphtha and diesel. The Fischer-Tropsch condensate containing the reduced amount of oxygenates may be added to the catalytic mixture or the catalyst may be added to the condensate feed. In either case, the feed and the product formed during oligomerization will form a separate phase from the ionic liquid which allows the product to be readily separated from the ionic liquid catalyst. In order to facilitate mixing of the ionic liquid catalyst and the feed, it is desirable to either stir the oligomerization mixture or bubble the condensate feed through the ionic liquid catalyst. Following completion of the oligomerization reaction, the mixing should be halted, and the product and residual feed should be allowed to form a distinct layer apart from the catalyst phase.

The ionic liquid oligomerization catalyst used in this invention will be a Lewis acid catalyst and usually will comprise at least two components which form a complex. In most instances, the catalyst will be a binary catalyst, i.e., it will consist of only two components. The first component of the catalyst will usually comprise a Lewis acid selected from the group consisting of aluminum halide, alkyl aluminum halide, gallium halide, and alkyl gallium halide. Preferred for the first component is an aluminum halide or alkyl aluminum

1 halide. Aluminum trichloride is particularly preferred for preparing the
2 oligomerization catalyst used in practicing the present invention. The
3 presence of the first component should give the ionic liquid a Lewis (or
4 Franklin) acidic character.

5
6 The second component making up the catalyst is usually a quaternary
7 ammonium or quaternary phosphonium compound, such as, for example, a
8 salt selected from one or more of hydrocarbyl substituted ammonium halides,
9 hydrocarbyl substituted imidazolium halide, hydrocarbyl substituted pyridinium
10 halide, alkylene substituted pyridinium dihalide, hydrocarbyl substituted
11 phosphonium halide. Preferred for use as the second component are those
12 quaternary ammonium halides containing one or more alkyl moieties having
13 from 1 to about 9 carbon atoms, such as, for example, trimethylamine
14 hydrochloride, methyl-tributyl ammonium chloride, or alkyl substituted
15 imidazolium halides, such as, for example, 1-ethyl-3-methyl-imidazolium
16 chloride.

17
18 The mole ratio of the two components will usually fall within the range of from
19 about 1:1 to about 5:1 of said first component to said second component, and
20 more preferably the mole ratio will be in the range of from about 1:1 to about
21 2:1. The use of a binary catalyst composition consisting essentially of
22 methyl-tributyl ammonium chloride and aluminum trichloride is particularly
23 advantageous for carrying out the process of the present invention due to the
24 ease of preparation, the ready commercial availability of the components, and
25 the relatively low cost.

26
27 The amount of catalyst present to promote the oligomerization of the olefins
28 should be not less than an effective oligomerizing amount, that is to say, the
29 minimum amount of the catalyst necessary to oligomerize the olefins to the
30 desired product. This may vary to some degree depending on the composition
31 of the catalyst, the ratio of the two components of the catalyst to one another,
32 the feed, the oligomerization conditions chosen, and the like. However, a
33 determination of the effective catalytic amount should be well within the ability

1 of one skilled in the art with no more than routine testing necessary to
2 establish the amount needed to carry out the invention. As noted above,
3 make-up catalyst added to the oligomerization zone may be necessary to
4 replace catalyst that is deactivated by contaminants in the feed, mostly
5 residual oxygenates present in the wax fraction. The amount of make-up
6 catalyst necessary will depend on the amount of contaminants present.
7 Preferably, the amount of contaminants will be low and the degree of
8 deactivation of the catalyst also will be low.

9
10 The oligomerization reaction takes place over a wide temperature range
11 between the melting point of the catalyst and its decomposition temperature,
12 preferably between about 120 degrees F and about 212 degrees F (about
13 50 degrees C and about 100 degrees C).

14
15 Following completion of the oligomerization reaction, the organic layer
16 containing the Fischer-Tropsch derived oligomerization product is separated
17 from the ionic liquid phase. Preferably, the oligomerization product will have
18 an average molecular weight at least 10 percent higher than the initial
19 olefin-enriched Fischer-Tropsch feedstock, more preferably at least
20 20 percent higher. The acidic ionic liquid catalyst that remains after recovery
21 of the organic phase is preferably recycled to the oligomerization zone.

22 23 Hydrofinishing

24
25 Hydrofinishing operations are intended to improve the UV stability and color of
26 the Fischer-Tropsch derived products recovered from the oligomerization
27 zone. It is believed this is accomplished by saturating the double bonds
28 present in the hydrocarbon molecule. A general description of the
29 hydrofinishing process may be found in U.S. Patent Nos. 3,852,207 and
30 4,673,487. As used in this disclosure, the term "UV stability" refers to the
31 stability of the lubricating base oil or other products when exposed to
32 ultraviolet light and oxygen. Instability is indicated when a visible precipitate
33 forms or darker color develops upon exposure to ultraviolet light and air which

1 results in a cloudiness or floc in the product. Lubricating base oils and diesel
2 products prepared by the process of the present invention will require UV
3 stabilization before they are suitable for use in the manufacture of commercial
4 lubricating oils and marketable diesel.

5
6 In the present invention, the total pressure in the hydrofinishing zone will be
7 above 500 psig, preferably above 1000 psig, and most preferably will be
8 above 1500 psig. The maximum total pressure is not critical to the process,
9 but due to equipment limitations the total pressure will not exceed 3000 psig
10 and usually will not exceed about 2500 psig. Temperature ranges in the
11 hydrofinishing zone are usually in the range of from about 300 degrees F
12 (150 degrees C) to about 700 degrees F (370 degrees C), with temperatures
13 of from about 400 degrees F (205degrees C) to about 500 degrees F
14 (260 degrees C) being preferred. The LHSV is usually within the range of from
15 about 0.2 to about 2.0, preferably 0.2 to 1.5, and most preferably from about
16 0.7 to 1.0. Hydrogen is usually supplied to the hydrofinishing zone at a rate of
17 from about 1000 to about 10,000 SCF per barrel of feed. Typically, the
18 hydrogen is fed at a rate of about 3000 SCF per barrel of feed.

19
20 Suitable hydrofinishing catalysts typically contain a Group VIII noble metal
21 component together with an oxide support. Metals or compounds of the
22 following metals are contemplated as useful in hydrofinishing catalysts include
23 ruthenium, rhodium, iridium, palladium, platinum, and osmium. Preferably, the
24 metal or metals will be platinum, palladium or mixtures of platinum and
25 palladium. The refractory oxide support usually consists of silica-alumina,
26 silica-alumina-zirconia, and the like. Typical hydrofinishing catalysts are
27 disclosed in U.S. Patent Nos. 3,852,207; 4,157,294 and 4,673,487.